

VAPOR PHASE TECHNOLOGY AND ITS APPLICATION.

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ABSTRACT.

Vapor phase, once cast to the annals' of history is making a comeback. Why? Reflow technology is well developed and has served the industry for many years, it is simple and it is consistent.

All points are true – when dealing with the centre section of the bell curve. Today's PCB manufacturers are faced with many designs which no longer fall into that polite category but rather test the process engineering groups with heavier and larger panels, large ground planes located in tricky places, component mass densities which are poorly distributed, ever changing Pb Free alloys and higher process temperatures. All the time the costs for the panels increase, availability of "process trial" boards diminishes and yields are expected to be extremely high with zero scrap rates.

The final process in the assembly line has the capacity to secure all the value of the assembly or destroy it. If a panel is poorly soldered due to poor Oven setup or incorrect programming of the profile the recovery of the panel is at best expensive, at worst a loss.

For these challenges people are turning to Vapor Phase. Why?

Keywords: Pb free, Backplanes,

INTRODUCTION.

United States Patent [19] [11] **3,866,307**
Pfahl, Jr. et al. [45] **Feb. 18, 1975**

[54] **METHOD FOR SOLDERING, FUSING OR BRAZING** 3,080,648 3/1963 Thomas 29/498 X
3,263,325 8/1966 Jacobson 29/498
3,409,978 11/1968 Grams 29/498

[75] Inventors: Robert Christian Pfahl, Jr., Chester; Hans Hugo Ammann, Morris, both of N.J.

[73] Assignees: Western Electric Company, Incorporated, New York, N.Y.; Bell Telephone Laboratories, Incorporated, Murray Hill, N.J.

[22] Filed: Sept. 7, 1973

[21] Appl. No.: 395,310

[52] U.S. Cl. 29/498, 228/37, 228/34
[51] Int. Cl. B23k 31/02, B23k 1/08, B23k 1/00
[58] Field of Search 29/498; 228/34, 37

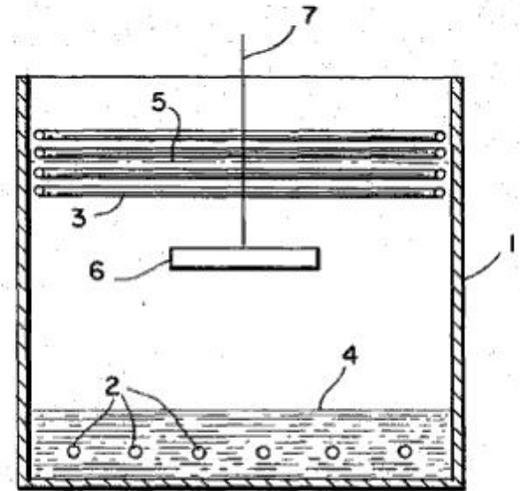
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Primary Examiner—Harrison L. Hinson
Attorney, Agent, or Firm—Jack Schuman

[57] **ABSTRACT**
Article to be soldered, fused or brazed is placed in hot saturated vapors generated by continuously boiling heat transfer liquid having selected properties including boiling point at least equal to, and preferably above, temperature required for operation. Vapors condense on article and give up latent heat of vaporization to heat article to temperature for soldering, fusing or brazing. Heat transfer liquid may be a fluorocarbon. Apparatus is shown for soldering, fusing or brazing a single article, a batch of articles, or a continuously moving line of articles. Specifically, mass reflow soldering and mass wave soldering operations are described.

17 Claims, 4 Drawing Figures

overviewed in the patent abstract are still valid.



Conceptual batch machine

As SMD components and PCB designs evolved Vapor Phase presented the only realistic reflow solution and for a number of years was widely deployed across large and small companies who were leading the technology revolution and the use of SMT.

The relegation of Vapor Phase to the point of technical obscurity was expedited by Ozone depletion issues, significant engineering challenges with in-line deployment as well as the costs associated with the Fluids used. IR technology advanced and ultimately evolved into Convection technology and it assumed the dominant position.

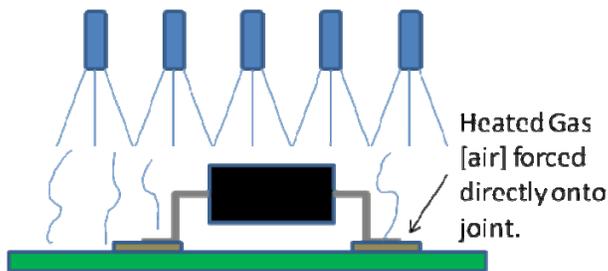
The technology survived in the wings of our industry, and was bused used by those challenged with the most complex or expensive PCBs; PCBs that simply cannot be profiled before they are run in production because they are too expensive and sensitive, they are too heavy for a traditional reflow system or there are simply too few in number to afford iterative process development. Today those same issues are more prevalent again in USA manufacturing companies, costs are rising rapidly and the need for a higher level of confidence in first time yields drives Vapor Phase to the top of the list when determining "How" to reflow high cost, high complexity PCBs.

Vapor phase as a soldering process was first used in the early 1970's and patented by Robert Christain Pfahl and Hans Hugo Ammann of Western Electric and Bell Labs. The patent today is 34 years old and in large part its claims as

PFPE's, the fluids used today are utterly inert and are in widespread use in the semiconductor and medical fields amongst others. They are a Liquid polymer rather than solvent and do NOT present any Ozone or ecological threat.

Vapor Phase thermal profiling capability is equal to that of any convection system today the need to pre-heat outside the Vapor system is redundant. This makes for a simpler machine design and a significantly simpler process. A One stop capability that allows the PCB to be preheated in a controlled vapor environment which in turn translates to a zero Oxygen process.

The complete eradication of Oxygen from the process allows flux chemistry to operate in an ideal environment without need to be concerned about a rear guard action of heated air being blown down on the joints.

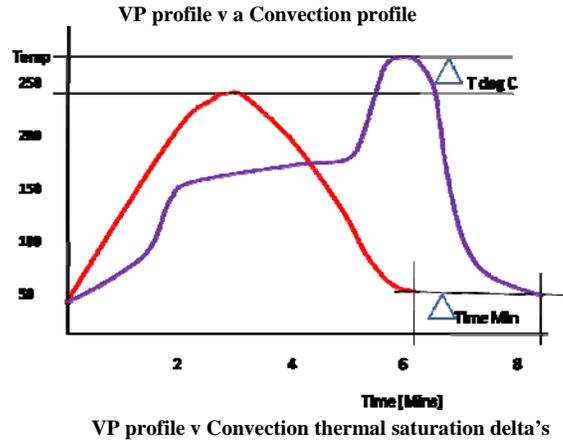
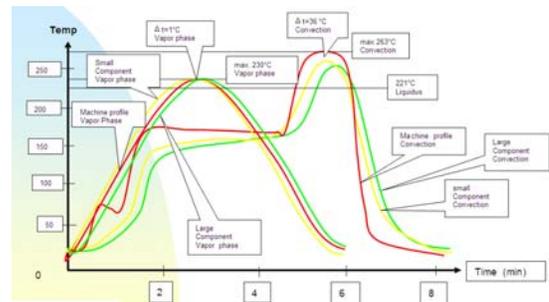


Convection processes cause Oxidation issues.

Flux efficiency is improved and ultimately a possibility to re-engineer paste composition to minimize flux residues and activity levels presents itself.

Given that the Fluid Medium boiling point is the governing factor in peak temperatures. [Latent heat transition results in a change of state but not a change in temperature.] The absolute maximum any circuit can reach is governed by a physical constant.

Over all thermal saturation time is a key to product reliability that is often overlooked. In the convection process, in an attempt to reach adequate minimum temperatures for particular parts which do not ramp at a normal rate all low mass parts will rise in temperature at a rate far in excess of the panel and its heavier mass parts. However – they will not stop rising as they would in Vapor Phase. They will continue toward the source temperature which will be significantly higher than the optimal process parameters. The typical second stage of a Convection profile is designed to mitigate the Delta across the Panel before acceleration and rise to liquidous. This adds time to the process, increasing the overall thermal saturation period for the whole panel and significant exposure to extreme temperatures for smaller components.



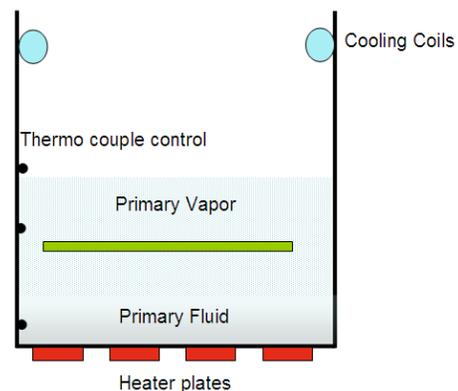
VP profile v Convection thermal saturation delta's

The purpose of this summary is to introduce the various points that differentiate Vapor Phase and a Physical process relative to convection systems. Secondly to discuss where issues found in convection maybe overcome by simply changing the reflow system to one of Vapor Phase.

Today's System Design - overview

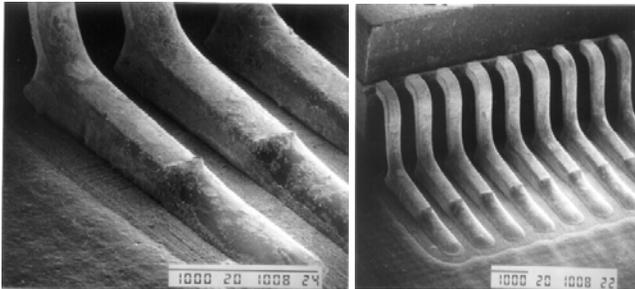
Saturated vapor phase soldering systems feature cutting edge technology with their variable temperature gradient control in saturated vapor. These systems provide process reliability and repeatability exceeding all convection systems. With External heat sources the machines offer simplistic operational characteristics and excellent reliability. Available as either standalone or in-line systems

Current Production VP System

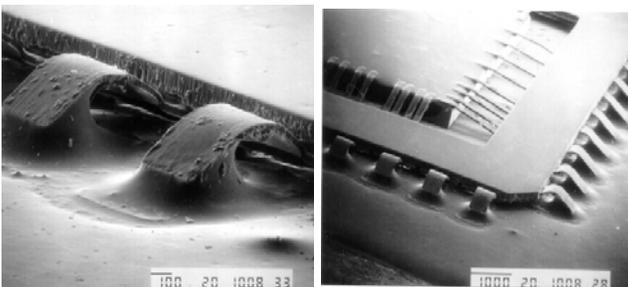


today's machine designs have also minimized the associated machine maintenance requirements with continuous filtration systems, flux traps and external heat banks. All of which make the systems adaptation to volume production environments practicable and cost efficient for many companies producing higher value PCBs.

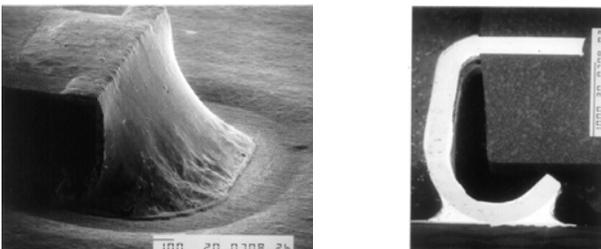
The thermo couple control with imbedded thermal management enable the machines to "sense" a situation where a PCB is incorrect to the established profile and protect against either excessive time or too short a time in the system. Qualified as an Auto Solder Break this feature is the ultimate insurance against operator error and PCB damage.



Optimal fillet formation on SOIC



Optimal fillet formation on Flat Packs



Optimal fillet formation on Chip components and J lead devices

Vapor Phase Application – areas of benefit.

Lead free: The added demands of temperature have been shown to seriously challenge the very best convection systems on the market with temperature differentials often exceeding 20 degs C. The physical regularity of Vapor Phase insures ALL parts on the circuit and the circuit itself will not exceed the fluid boiling point and that all parts will converge at the fluid boiling point. Thus guaranteeing parts will not be damaged by excessive heating and that joint structure will not

be impacted by inadequate temperature or time at temperature.

A facet of leaded reflow enjoyed by all manufacturers is the natural tendency of parts to centre themselves when twisted or off centre from the pads. This phenomenon does not typically occur in a Convection System when faced with a lead free process. The Vapor Phase process with the benefit of being Zero Oxygen once again creates the correct environment of higher surface tension effects on the joint and the natural equalization of forces in the joint once liquidous self centers the devices. The reality of joints being off the pads can be corrected in any number of ways but what this does illustrate is the true nature of an Oxygen free environment and all the real benefits to joint integrity it brings.

Batch of One: Batch size of one talks to a manufacturing philosophy but today in the innovative and fast paced world of product development a batch of one is common. Usually a test vehicle it simply has to function mechanically. So running it through an arbitrary process is un-acceptable. Vapor Phase machines present an opportunity to simply watch the process as it occurs. By watching the product go to liquidous and terminating the process after an appointed time above liquidous insures against dry joints. The Vapor Phase process insures against excessive temperatures being reached.

Extremes of Mass and surface area: Backplanes are some of the heaviest PCBs in production today and represent significant thermal challenges. Convection systems have a limited capability to be scaled and suffer thermal irregularities when faced with extremes of surface area. Today Vapor Phase systems are handling PCBs in excess of 3ft in length and have the capability to be scaled to handle even larger panel dimensions. They are equally well suited to the extremes of mass. It is not uncommon for PCBs to be fixtured today, the fixtures being in place to maintain position of key components that may have a tendency to shift. Fixtures are heavy and invariably do not distribute their mass equally creating thermal sinks. Any liquidous thermal transfer system benefits from a thermal conduction efficiency 10 times that of a gaseous based system and can readily accommodate such loads.

Rework of large devices: Is always challenging and presents the worst case scenario. With a simple cantilever device it is possible to lift high mass parts off of a PCB within the Vapor Phase machine. The peak temperature of the part again cannot exceed that of the liquid boiling point and so no threat of delamination of the PCB or damage to local supplemental parts is assured. The zero oxygen environment ensures joint and intermetallic integrity.

Low Volume high mix: Production facilities operating in a high frequency of changeovers would usually be faced with conveyor and possibly profile changes before running a different PCB part number. Vapor Phase allows multiple PCB part numbers of varying sizes and masses to be run simultaneously allowing a far higher utilization of production assets and material flows in a difficult environment.